Employing Linked Data and Dialogue for Modelling Cultural Awareness of a User

Ronald Denaux[1], Vania Dimitrova[1], Lydia Lau[1], Paul Brna[1], Dhaval Thakker[1] and Christina Steiner[2]

[1]School of Computing, University of Leeds, United Kingdom.

[2]Knowledge Technologies Institute, Graz University of Technology, Austria.

{r.denaux, v.g.dimitrova, l.m.s.lau, d.thakker}@leeds.ac.uk, paulbrna@mac.com, christina.steiner@tugraz.at

ABSTRACT

Intercultural competence is an essential 21st Century skill. A key issue for developers of cross-cultural training simulators is the need to provide relevant learning experience adapted to the learner's abilities. This paper presents a dialogic approach for a quick assessment of the depth of a learner's current intercultural awareness as part of the EU ImREAL project. To support the dialogue, Linked Data is seen as a rich knowledge base for a diverse range of resources on cultural aspects. This paper investigates how semantic technologies could be used to: (a) extract a pool of concrete culturally-relevant facts from DBpedia that can be linked to various cultural groups and to the learner, (b) model a learner's knowledge on a selected set of cultural themes and (c) provide a novel, adaptive and user-friendly, user modelling dialogue for cultural awareness. The usability and usefulness of the approach is evaluated by CrowdFlower and Expert Inspection.

Author Keywords

User modelling; dialogue system; linked data; cultural awareness; learning simulator.

ACM Classification Keywords

H.5 Information Interfaces and Presentation; I.2.4 Knowledge Representation Formalisms and Methods; I.3.6 Methodology and Techniques.

INTRODUCTION

Intercultural competence is an important skill in today's globalised world, and is becoming recognised as a key aspect when designing user-adaptive interactive systems and intelligent user interfaces in various domains. To adapt to cultural diversity, these systems would need to encompass robust user modelling mechanisms which should be developed and tested in representative domains. For example, the EU ImREAL project[1] which aimed to extend a learner's cultural awareness by linking to more real-life experiences.

Culture can be defined as a set of beliefs, values, behaviours and practices that characterise a given group of people [6]. The ability of being aware that there may be differences in any of these aspects and their influence by culture is important in effective interpersonal communications. According to Hofstede [4], cultural awareness is the first step towards gaining intercultural competences. It has been well-recognised that culture is a complex and ill-defined domain [1]. A way to tackle the complexity of introducing culture into intelligent interactive systems is to focus on a specific aspect, which usually aligns with the possible application.

In this line of thought, the approach presented here has selected nationality as the aspects for culture, and looks at a user's cultural awareness regarding a specific nationality (as specified by the country). This is aligned with studies in which point out that nationality and countries are reliable indicators for tackling cultural diversity [3]. Several topics attributed to national culture were identified – gestures, food, clothes as well as general knowledge about the country's socio-political system. The paper focuses on modelling a user's knowledge in these cultural topics, which we will call cultural awareness hereafter.

A key challenge in providing culture-aware adaptation is the system's ability to derive a reliable model of the user's cultural awareness. This is the well-known cold start problem. A feasible approach to tackle cold start in interactive learning systems is via probing dialogue which step by step builds up a profile of the learner.

Having a rich knowledge base is important for planning a meaningful dialogue. However, knowledge base authoring is an expensive and time consuming process. The traditional approaches develop bespoke solutions by involving relevant experts, often leading to 'knowledge

[1] http://www.imreal-project.eu/

bottleneck' [8]. Recent approaches begin to examine the possibility of reusing knowledge that already exists in digital forms (e.g. Linked Data) and even combining with dialogue systems [8]. New effort, such as LinkedUp, has been made to adopt this Linked Data approach for education [7]. While some have explored the cultural knowledge domain, there are no existing approaches that employ linked data for modelling user cultural awareness.

It is in this gap that the proposed approach makes its key contribution to user-adaptive learning environments, and to the general field of culture-aware intelligent adaptive systems. An ontology-based dialogue agent, Perico, probes and extracts a user's cultural awareness of selected countries by using Linked Data (in this case DBpedia) as the knowledge base. As it uses a diverse range of cultural concepts and facts, a richer user model can be generated. The paper addresses the following research question: 'How to utilise DBpedia effectively for the construction of a knowledge base that drives a dialogue agent for modelling a user's cultural awareness?'

The key aspects of the work reported here include a) the potential for the work to be utilised by many applications to derive a moderately accurate knowledge of the cultural awareness of the user; and b) the potential for the use of externally developed sources of (possibly inaccurate) knowledge about cultures rather than relying on estimates of Hofstede's five dimensions – often carried out via a lookup in a table based on the user's nationality.

OVERVIEW OF THE DIALOGUE AGENT – PERICO

Perico is a dialogue agent that interacts with the user through a chat like interface. The dialogue agent provides a set of knowledge probing and modeling dialogue plans which lead the conversation in a direction that enables (a) validation of part of the existing user model and (b) extension of the user model. It is an implementation of a generic dialogue framework [2] that can use OWL ontologies and RDF data as its knowledge base. Figure 1 shows the main components of the Perico dialogue agent which can be grouped as follow:

- Dialogue manager (centre of Figure 1) which provides the plan and grounding of the dialogue.
- Dialogue state and knowledge base (right hand side) which keeps track of state, tasks and moves; and operates on an ontology that contains concepts about cultural variations in interpersonal communication.
- Input, output and web interface (the remaining components on the left) which handle user interfaces.

CONSTRUCT KNOWLEDGE BASE FROM DBPEDIA

Dialogue systems require access to a knowledge base for preparing dialogue and performing assessment. In our case, the knowledge base needs to contain facts about different cultures. For meaningful interaction, it needs facts about a wide variety of cultural groups. Furthermore, users of all levels should be able to understand the assertions contained in the knowledge base (even if they do not know whether the assertions are correct or not).

Intercultural Fact Extraction from DBpedia

While the literature provided key concepts based on theoretical foundations, it largely neglects the concrete cultural variations and nuances that are necessary in order to converse with a learner. For extending the core ontologies and to achieve more concrete conceptualization, we have utilized DBpedia. The extraction of intercultural facts is not straightforward, because by default DBpedia does not directly link countries with cultural aspects (e.g. Clothing, Greetings etc.). However, it provides access to the crowd-sourced categorisation of Wikipedia pages which are used to infer cultural facts.

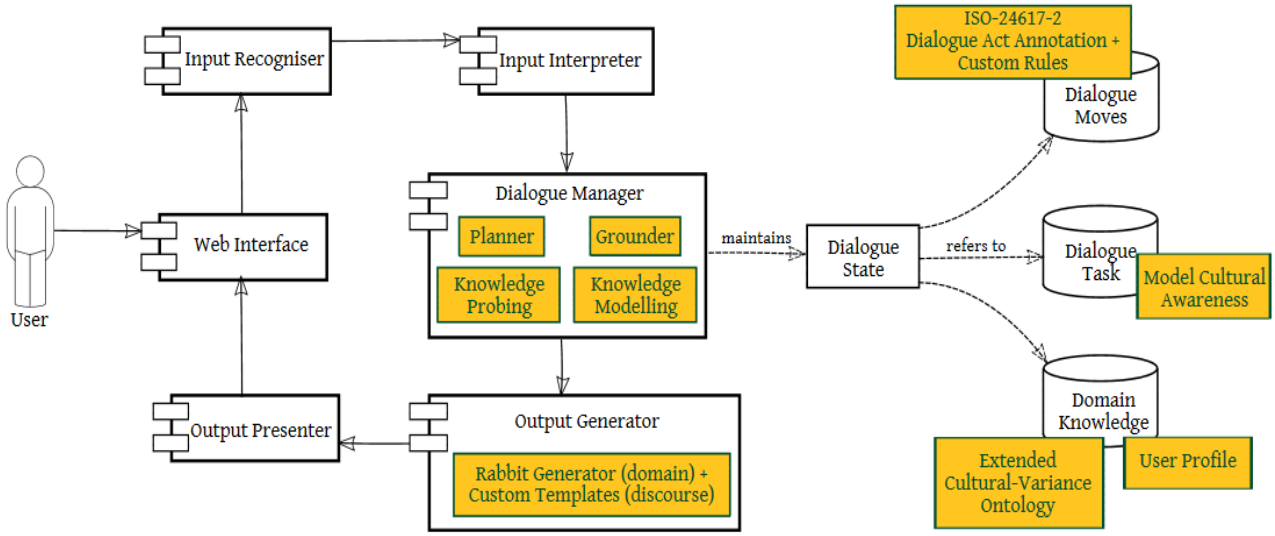

Figure 1 Component diagram for the culturally aware Perico. The main components (depicted in white) are typical of dialogue systems. Key services (shaded components) are put in place to enable the modelling of intercultural awareness.

In ImREAL, the AMOn+[2] ontology suite, developed using a theory-driven approach to conceptualize cultural variations in interpersonal communication activities [5], was used for the core vocabulary. The AMOn+ cultural variations module contains the concepts from various cultural theories and links them to Interpersonal Communication Module where appropriate. The module contains concepts such as *Cultural Norms*, *Stereotypes*, *Cultural Group* and *Behavior Primitives*.

DBpedia was used to extend the ontology with the following types of facts which have cultural variations: (a) non-verbal communication facts that relate gesture (including facial expressions and hand gestures) to a specific country, and by extension to a specific cultural group defined by nationality; (b) facts for eating norms that relate food items to countries; (c) facts for dressing norms that relate specific garments to specific countries. It was also beneficial to include other (non-cultural) facts that can be used to verify the knowledge of learners about a specific country, e.g. socio-political facts such as language and currency. Socio-political facts can easily be extracted from DBpedia since it contains a rich set of facts about countries. We used SPARQL queries to extract this knowledge[3].

In DBpedia, a page describes a topic, which may or may not be culturally relevant, and includes links to: (a) **Categories** defined for Wikipedia pages. Categories are linked to each other via sub-category relations. (b) **OWL Classes** defined in the DBpedia ontology[4] (such as Person, Organization, Music Genre, Sport, Language, Country and Currency). However DBpedia ontology does not contain culturally-relevant concepts such as *Greeting*, *Dressing* or *Food*. (c) **Literals** include human-readable labels and images of the topic of the page.

Extraction of DBpedia to extend the core modules is by: (a) Identifying categories that relate to concepts from the Cultural Variations module. (b) Traversing the DBpedia category network to find narrower pages with specific category and subcategories. (c) Traversing the DBpedia category network to find broader categories that are shared between the page to be extracted and a Country linked to them. (d) Inferring/adding new OWL axioms: a class assertion axiom linking the DBpedia page with an OWL class relevant to a concept from the Cultural Variations module; object property assertions linking the DBpedia page with one or more countries where this Cultural Variations concept occurs; and finally, copying relevant human-readable labels and depictions.

For example, to find concrete instantiations of the Cultural Variations module concept *Gestures*, DBpedia offers a category for Gestures[5], which has associated pages and subcategories (with their own pages). By traversing the category network, it is possible to find narrower pages like `dbpedia:Moutza`[6]. Furthermore, by searching for broader categories of `dbpedia:Moutza`, it is possible to find a category *Greek_Culture* and its super category Greece, which is connected to `dbpedia:Greece`, instance of a Country. This allows us to infer assertions that "`Moutza` is a `Gesture`" and that "`Moutza occursIn Greece`".

As the DBpedia category network is noisy, we apply a filter to the pages and subcategories to avoid unwanted resources. Our filter ignores resources and categories based on blacklisted parent categories or classes from the DBpedia ontology, such as OWL Classes (e.g. Person, Animal, Company) and DBpedia categories (e.g. Rooms, LivingPeople, BusinessLaw). For socio-political facts, Perico currently uses languages spoken in a country, currency, HDI (human development index) and GNI (Generalized inequality index).

Intercultural Fact Pool Generation

For a dialogue system, it is important that both types of facts, i.e. in assertive and negative forms, are available to probe a user. AMOn+ ontology suite contains assertions relating cultural aspects with specific countries (e.g. `Moutza occursIn Greece`). However, due to the Open World Assumption in OWL, it is not possible to know whether the same cultural aspects also occur in other countries (e.g. `Moutza occursIn Philippines`). In order to correctly model intercultural awareness we add extra (negation) assertions. We do this based on a list of countries that a learner may have visited to avoid generating large numbers of negation assertions. For example, if the learner has visited Greece and Germany, one of the assertions that will be generated is that "`Moutza` does not `occursIn Germany`". As with the facts extracted from DBpedia, it may be that links are simply missing from DBpedia or that our fact extraction algorithm failed to extract a fact. In such cases, the generated negation assertion will be incorrect.

USER EVALUATION USING CROWDFLOWER

This study examined Perico's usability. The main question addressed was: '*How do users perceive Perico's usability*?' 22 participants were recruited from CrowdFlower[7], and 4 participants recruited from the authors' institution.

The study involved: (a) *pre-study questionnaire*: for user profile information followed by an adapted version of the

[2] http://imash.leeds.ac.uk/ontologies/amon/
[3] http://dbepdia.org/sparql
[4] http://wiki.dbpedia.org/Ontology
[5] dbpedia.org/resource/Category:Gestures
[6] Moutza is a traditional hand gesture of insult in Greece.
[7] http://crowdflower.com/platform

Cultural Intelligence Scale[8] questionnaire (CQS); (b) *interaction with Perico*: for three countries; and (c) *post-study questionnaire*: repeated the adapted CQS questionnaire followed by an adapted System Usability Scale[9] (SUS) questionnaire. Participants from the authors' institution were followed-up with an interview.

Overall, the dialogue sessions covered 26 different countries in Europe, North and South America, Africa and Middle East. On average, 10 DBPedia entities were probed per dialogue session (average of 5 entities related to cultural aspects – gestures, food and clothes – and average of 5 entities related to socio-political aspects – language, currency, HDI, GNI); see Table 1.

Table 1 Distribution of DBPedia entities probed in Study 1 (total of 223 questions)

Gestures	Food	Clothes	Currency	Language	HDI	GNI
42	41	33	37	40	24	6

The participants' responses to the SUS questionnaire indicate that the participants found Perico quite usable and had no problems using it. The interviews with participants from the authors' institution resulted in following improvements: additional dialogue games to provide better feedback (e.g. indication of the correct answer and a list of countries for which the corresponding fact is correct); allow the users to indicate that the question may be confusing; more friendly tone of the dialogue; and acknowledge that content being derived from Wikipedia may not always be correct. The new version of Perico (see below) was used in the second user study, examining Perico's usefulness for user cultural awareness modelling.

EXAMPLE OF IMPROVED PERICO DIALOGUE

To illustrate the Perico components, a dialogue snippet extracted from the Expert Inspection evaluation study is presented below in which Zimbabwe was chosen by the user. Perico dialogue games are given in *italic*. The following response options were offered at every step: 'Yes', 'No', 'I don't know' or 'There's something wrong with this question'.

[Dialogue opening] *In this conversation I will ask you some questions about cultural aspects related to the countries you selected. The questions are based on facts I have learned from Wikipedia.*
[Episode opening] *Let's first discuss Zimbabwe.*
[Knowledge probing - Food] *Is it true that Makdous is a typical dish in Zimbabwe?*

<<a picture with the dish>>

User: No.

[Feedback] *I agree, Wikipedia does not state this either. Makdous occurs in Jordan, Arab Federation, Mandatory Palestine and 33 other countries.*

[Knowledge probing - Language] *Is it true that Rama Cay Creole is spoken in Zimbabwe.?*
User: I don't know

[Feedback] *This is probably not true since Wikipedia does not contain this fact, maybe that's why you didn't know the answer. Rama Cay Creole is spoken in Nicaragua.*

[Dialogue continues…]

[Episode closing] *Your exposure to Zimbabwe is OK.*

I asked you a total of 23 questions. Based on these questions, I think your overall cultural awareness is OK. Here's a breakdown of your score by topic:

Your knowledge about gestures is very good (based on 5 questions). Your knowledge about food needs improvement (based on 5 questions). Your knowledge about clothing is OK (based on 5 questions). 3 questions were on socio-political facts, your knowledge there is OK.

Your knowledge about currencies is unknown (based on 0 questions). Your knowledge about human development is very good (based on 1 question). Your knowledge about income inequality is very good (based on 1 question). Your knowledge about languages spoken in the various countries is not good (based on 1 question).

EVALUATION USING EXPERT INSPECTION

This study examined Perico's suitability for modelling user cultural awareness involving expert inspection. It addressed two questions: '*Does Perico produce an accurate user model?'* and *'What is the utility of the knowledge content for user cultural awareness modelling?*'

Two experts[10] were involved. Both had experience in user modelling and user-adaptive interactive systems and with good cultural exposure. The inspection was based on a systematically selected pool of countries based on the GLOBE model [3]. The experts conducted 10 dialogue sessions each, ensuring that one country per GLOBE cluster was selected and with varying levels of cultural knowledge in the selected countries. Possible cultural knowledge levels were: *none* (no encounter with the national culture), *low* (short visits to the country; limited contacts with people from this culture), *medium* (living in the country for a short period; sequence of regular short visits; some relationships with people from this nationality), and *high* (living in the country for a while; strong relationships with people from this nationality).

The total number of knowledge probing games in the 20 Perico dialogues was 457 (average per session = 22.85, STDV=0.6). The individual sessions were approximately twice longer than the sessions in CrowdFlower Study – this is because we changed the dialogue goals to discussing all seven DBPedia topics. Each session included one question on HDI and GNI and an average of 3 questions on language and currency and 5 questions on gestures, food and clothes.

[8] http://www.linnvandyne.com/fourfac.html
[9] http://www.measuringusability.com/sus.php

[10] Members of the project team who were not involved in the development of the Perico system.

User model accuracy. The experts inspected their cultural knowledge models generated by Perico at the end of the dialogue for each country (see transcript example). Four possible levels of knowledge about a topic could be return by Perico: *not-good* (the user did not answer any question correctly), *need-improvement* (less than 50% correct answers), ok (correct answers 50-70%), very good (more than 70% correct answers). Ratings for the experts to indicate accuracy level of diagnosis were: *accurate* (agree with Perico's diagnosis of their knowledge on the corresponding topic for the discussed country), *underestimated* (Perico's cultural knowledge level was lower than expected) and *overestimated* (Perico's cultural knowledge level was higher than expected).

Figure 2 gives a summary. Perico was most accurate in judging the user knowledge on food (80%) and currency (70%), followed by gestures (65%) and clothes (60%). The experts felt Perico overestimated their knowledge when correct answers could be derived from clues in the questions (see the discussion on content utility below). An error with calculation of the user model scores for language was identified – although the user answered several questions about the language, only the correct answers on normal assertions were counted – this led to the low accuracy of this topic (Perico assigned 'unknown' knowledge levels). Knowledge on human development and inequality was not properly handled by Perico (based on one question only). In several cases there were misleading values for HDI, e.g. '123 human development' or 'n/a human development' (due to noise in DBpedia), and it was unclear what was meant by 'high income inequality' and 'very high income inequality' (for a layman user).

We further examined whether the expert's familiarity with the national culture influenced their judgment of the correctness of their knowledge about that culture (see Figure 3). Experts tended to approve Perico's values on gestures, clothes and language and food when they were familiar with the country. This confirms that Perico's assessment of these topics is fairly reliable. Regarding currency, the incorrect judgment was based on having low utility content (see discussion below). Regarding HDI and GNI, the experts suggested two possible improvements – (a) instead of directly probing for a fact from DBpedia, compose a list of countries with a similar level of HDI or GNI and ask the user to compare the country against the list; and (b) combine the questions on HDI and GNI, with additional questions about the socio-political system in the country. This will require further extending the DBPdia knowledge pool.

Knowledge content utility. The quality of the resultant user model, and the overall usefulness of the approach, is dependent on the suitability of the knowledge content (i.e. the generated assertions) for assessing user's knowledge on the selected topics.

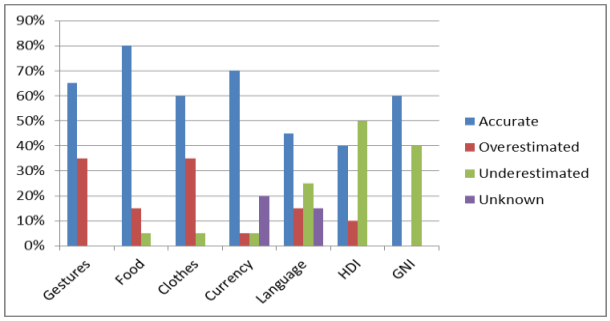

Figure 2 Summary of the experts' judgment of the accuracy of Perico's knowledge level (average values per each topic and dialogue session).

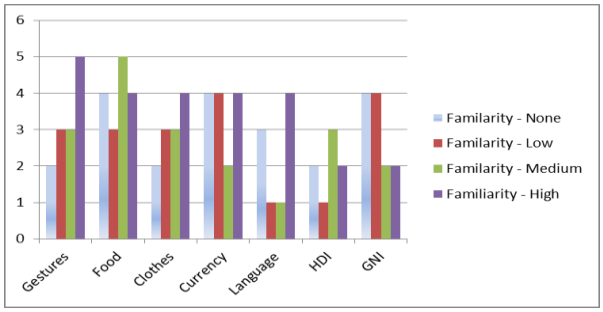

Figure 3 Frequency of cases when the experts judged that the Perico's assessment was accurate, grouped by user familiarity with the national culture.

To analyse this, the experts examined their dialogue transcripts and assigned a utility value for every knowledge probing question indicating the value of a correct answer given by the user to updating the user model. *Low utility* includes cases where the correct answer is explicitly indicated in the question (e.g. 'Is it true that Canadian Dollar is used in Canada?'). Such questions lead to inaccuracy in the user model. *Medium utility* includes cases where the correct answer can be given based on additional information in the question (e.g. the accompanying picture includes clues which help select/eliminate a country). Such questions are less cognitively demanding and in most of the cases give a good accuracy for user modelling. *High utility* questions are most valuable, as the correct answer requires good familiarity with the country culture.

The knowledge content has the highest utility for food (Figure 4). It is also suitable for gestures and clothes but leads to less cognitively demanding questions (e.g. being able to distinguish people looking as Asians or scenes which are related to Europe). While HDI and GNI were seen as usable, the limited amount of questions (only 20 per category) is insufficient to come to a conclusive answer.

The utility of currency and language questions was low – most of them superficially diagnosed a user's knowledge, as the answer could easily be guessed from the question.

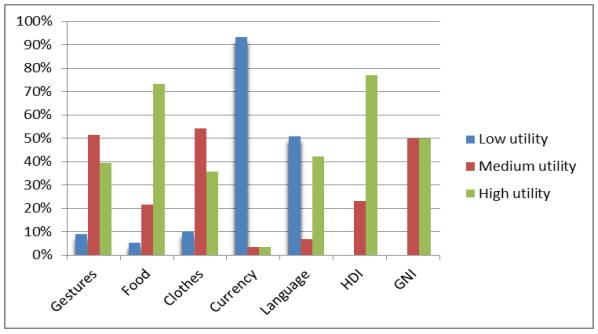

Figure 4 Knowledge content utility (% is based on the total number questions for the corresponding topic).

Further extension of Perico's knowledge probing mechanisms is needed to deal with low utility questions. The evaluation indicated some possible strategies. The first one is transforming the obviously correct statement by a syntactic transformation. For example, using currency nickname when exists in DBPedia (e.g. transforming 'Does Canada have currency Canadian dollar?' to 'Does Canada have currency loonie?') or using synonyms for entity labels. The second strategy is to go up in the ontology hierarchy (e.g. transforming 'Is Scottish Gaelic Language spoken in Scotland?' to 'Is Gaelic Language spoken in Scotland?'). For questions that are logically doubtful we need to find different solutions (e.g. 'Swedish language is spoken in Scotland' is not amenable to the three approaches described above). We can consider asking a different kind of question – such as 'Is a common kind of language shared between Sweden and Scotland?'. Similarities and dissimilarities between the ways in which countries have adopted various cultural practices can also be exploited.

CONCLUSIONS AND FUTURE WORK

The paper presents a novel approach for exploiting linked data and dialogue to deal with the cold start problem with modelling user cultural awareness. The approach is implemented in a dialogue agent Perico and has been validated in two user studies – using crowdsourcing and expert inspection. The combined findings of both studies give a strong support for the validity of the approach.

The first study indicated that layman users with various degree of cultural awareness find the system easy and intuitive to use. An in-depth expert inspection was conducted to examine the usefulness of the approach, considering the accuracy of the resultant user model and the utility of knowledge content. The inspection showed that Perico produces fairly reliable judgment of the user's knowledge of gestures, food and clothing associated with national cultures. For these topics, the extracted knowledge content had good utility (high-medium). The key challenge with modelling user's knowledge in language and currency is the low utility of generated assertions, i.e. including the country name in the question. Several strategies have been proposed for increasing the value these questions by extending Perico's knowledge probing mechanism. There was insufficient knowledge poll for human development and inequality, requiring a further knowledge extraction from DBpedia.

Our future plans for extending Perico include looking at cross-cultural modelling taking into account other countries - not just finding out what the learner knows about a specific country but also what they know about neighbouring countries and countries that are similar/dissimilar in a number of ways (e.g. GLOBE). Eventually there is the possibility of going beyond the concept of national cultures and moving to other, perhaps more complex notions of culture. For example, seeking to understand what learners know about how minorities differentiate themselves/merge with others.

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